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There were two major objectives of our research under grant AFOSR-88-0219. The first part of our research concerned perceptual grouping. The goal here is to segment an image into its perceptual components or segments. Such perceptual structure may exist at a range of resolutions. In the second part of our research we were concerned with a computational theory for an integrated representation of texture that takes into account many relevant aspects of texture, rather than just the properties of the texture elements at one level of resolution addressed in the past work. We have made progress towards both of the above mentioned objectives.

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Final Report to the Air Force Office of Scientific Research

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PERCEPTUAL STRUCTURE AND SHAPE FROM TEXTURE

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There were two major objectives of our research under grant AFOSR-88-0219. The first part of our research concerned perceptual grouping. The goal here is to segment an image into its perceptual components or segments. Such perceptual structure may exist at a range of resolutions. In the second part of our research we were concerned with a computational theory for an integrated representation of texture that takes into account many relevant aspects of texture, rather than just the properties of the texture elements at one level of resolution addressed in the past work. We have made progress towards both of the above mentioned objectives.

We have extended our integration approach for perceptual grouping to extract perceptual structure in gray level images. Analogous to the original approach which was applied to dot patterns, the extended approach infers the structure by integrating evidence from region boundaries and region interiors. A large region considered homogeneous may contain regions deemed homogeneous at their own scales. The evidence for region interior is derived by using the multisacle region detector we developed earlier for the shape-from-texture problem. Region borders are also extracted at multiple resolutions, using a nonisotropic edge operator. In integrating the region interior and border information, the region boundary is forced to be smooth using explicit constraints to that effect.

Although the constraints integrated in our approach are all desirable in a Gestalt sense, we have carried out a quantitative analysis of their significance in defing a perceptual segmentation. We have conducted experiments with a set of dot patterns designed to satisfy to different degrees the different constraints: interior homogeneity, border smoothness, and component compactness. The segmentation results obtained by our algorithm for various combinations of these properties are then compared with the perceptual segmentation of these dot patterns. The two segmentations are usually the same. Further, we have compared the results of our approach with those obtained by traditional clustering algorithms. These results show that the global optimization of some simple function of interdot distances which is used as the criterion function by the clustering algorithms does not lead to perceptually acceptable segmentation. Our integration approach appears to give satisfactory performance in all the tests, supporting the use of the Gestalt criteria and the basic representation used in our algorithm.

We have used the regions derived as a result of the perceptual segmentation step as candidate texture elements for the recovery of surface orientation. The motivation for this is that the better the extracted regions estimate the true texture elements, the better will be the performance of the shape from texture approach. In these experiments, we have used the gradient of texture element area to estimate the surface orientation. The segmentation process does not extract regions whose shapes are sufficiently accurate for use in measurement of properties such as aspect ratio and foreshortening.